Advanced Component Technology Program

Metamaterial-based, Low SWaP, Robust and High Performance Hyperspectral Sensor for Land and Atmospheric Remote Sensing

Completed Technology Project (2018 - 2020)

Project Introduction

(a) Phoebus Optoelectronics' primary objective is to develop a hyperspectral imaging technology, the Metamaterial Spectrometer (MS), which minimizes the tradeoffs between performance and the size, weight, and power (SWaP). Our MS technology provides a competitive advantage over conventional optical systems, by enabling the sensor to be more narrowly targeted the spectral bands of interest for measuring trace gases and aerosols in the earth's atmosphere. Additional objectives that will be met are: 1. Demonstrate a SWaP reduction relative to current hyperspectral systems. 2. Demonstrate improved spectroscopic performance relative to current systems. 3. Produce sensor datasets to quantify atmospheric constituents, or spectral indices for land and vegetation characterization. 4. Produce sensor datasets of gases relevant to earth science measurements of the atmosphere. 5. Minimize the total cost of the hyperspectral sensing system, while maintaining state-of-the-art performance. 6. Demonstrate reduction in data processing times, as a result of spectral channel optimization and bandwidth performance of the metamaterial. 7. Provide a framework and testing platform, to tailor future iterations of the technology to specific sensing missions. 8. Develop the fundamental concepts of the technology to expand it to other spectral bands, from the visible to the LWIR. The anticipated benefits of the proposed technology are: 1. Incorporating many pixel-scale filters eliminates the need for a dispersive element within the system. 2. Selectable channels with varying passbands measure only desired channels, shrinking detector, electronics, and data rate needs. 3. Compatibility with fast optical systems makes best use of available signal, minimizing aperture size for a given measurement performance. 4. Enable hyperspectral filtering technology to be used with miniature space platforms such as CubeSats. 5. Provide a flexible and cost-minded hyperspectral imaging platform for a variety of spectral bands. 6. Extend the MS technology for use in space-based applications such as long-range laser communication. (b) The outline for the proposed work and methodology is as follows: 1. Simulate the MS filter design, from the unit cell to the finite scale structures, using industry standard electromagnetic simulation software, to optimize in-band transmission and out-of-band rejection. 2. Fabricate optimized designs using standard CMOS micro-fabrication technologies. 3. Optically characterize fabricated test structures, and compare performance to simulated predictions. 4. Use optical characterization data to refine simulations, optimize designs, fabricate improved test structures, and repeat optical tests. 5. Iterate step 4 until test structures demonstrate performance required for a prototype level device. 6. Fabricate and optically characterize the full prototype filter as a standalone device. 7. Integrate the MS filter into a complete optical system for more in-depth, system-level testing (to be performed by our industry partner.) 8. Quantify relevant performance data of the prototype system, and estimate the improvement to earth science measurements. (c) Period of performance: 3 years (d) Entry TRL 2, Exit TRL 5

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Phoebus Optoelectronics, LLC

Responsible Program:

Advanced Component Technology Program

Metamaterial-based, Low SWaP, Robust and High Performance Hyperspectral Sensor for Land and Atmospheric Remote Sensing

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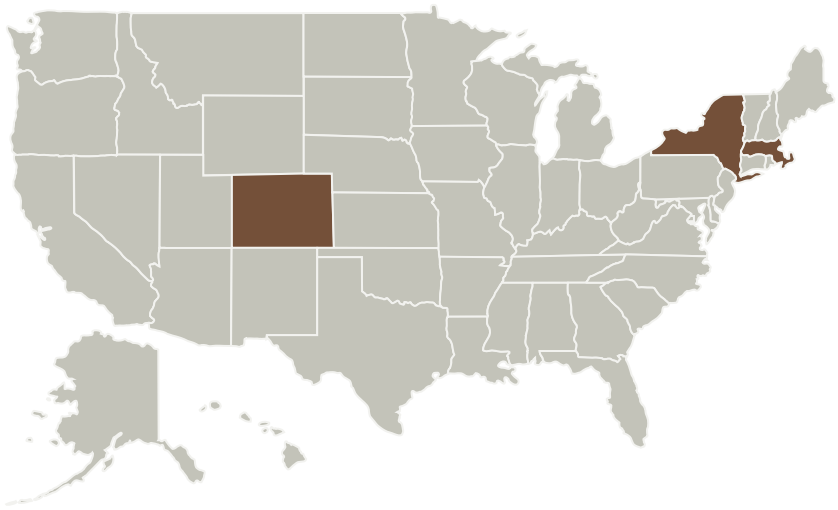
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Phoebus Optoelectronics, LLC	Lead Organization	Industry	Brooklyn, New York
AER, Inc.	Supporting Organization	Industry	
Ball Aerospace & Technologies Corporation	Supporting Organization	Industry	Boulder, Colorado
Clarkson University	Supporting Organization	Academia	Potsdam, New York

Primary U.S. Work Locations	
Colorado	Massachusetts
New York	

Project Management

Program Director:

Pamela S Millar

Program Manager:

Amber E Emory

Principal Investigator:

Igor Bendoym

Co-Investigators:

Derek J Kosciolek
Lori Lepak
James Leitch
Hilary E Snell
David T Crouse
Nicole Avallone

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Earth